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5-9535

Title of the Invention: METHOD FOR DISPERSING BUNDLE OF FILAMENTS

1. Claims

1. A method for dispersing filaments by allowing filament groups to pass through a corona discharge electric field formed by a corona discharge unit comprising a corona discharge electrode and target electrode together with an air stream to endow the filaments with an electrostatic charge, wherein dissipation of the electric charge on the filament groups is prevented using a plurality of the corona discharge units to form an air curtain flow along the target electrode at the last corona discharge unit of the plural corona discharge unit.

2. A method for dispersing filament groups according to Claim 1, wherein the corona discharge electrode for forming corona discharge electric field is a needle electrode, and the target electrode is a planar electrode.

3. A method for dispersing filaments by allowing filament groups to pass through a corona discharge electric field formed by a corona discharge unit comprising a corona discharge electrode and target electrode together with an air stream to endow the filaments with an electrostatic charge, wherein a plurality of corona discharge units are used in order to enable the corona voltage to arbitrarily adjust, and the space between the corona discharge electrode and the target electrode in each corona discharge unit gradually increases along the running direction of the filament groups, an air curtain flow being formed along the target electrode of the final corona discharge unit of the plural corona discharge unit to prevent dissipation of the electric charge.

4. A method for dispersing filament in the filament group according to Claim 3, wherein the corona discharge electrode for forming corona discharge electric field is a needle electrode, and the target electrode is a planar electrode.

5. A method for dispersing filaments in the filament group according to Claim 3, wherein the planar electrodes are formed into steps along the running direction of the filament groups, an air curtain flow being formed at the step formed between the final planar electrode and the planar electrode immediately before the final electrode along the final planar electrode face, thereby preventing dissipation of the electric charge.

2. Detailed Description of the Invention

The present invention relates to a method for dispersing filaments in the filament groups

In more detail, the present invention relates to a method for favorably dispersing filaments in the filament group by applying an extremely high electrostatic charge to the filament groups.

Filaments should be completely separated to one another (referred as dispersion of the filaments hereinafter) for obtaining a good quality nonwoven web in the method for forming a nonwoven fabric by dispersing and depositing a plurality of filaments that is transferred together with air on a conveyer. The technology usually used for this method comprises endowing the filament groups with an electrostatic charge by contact charging caused by friction or collision, or by corona discharge, and dispersing individual filaments by mutual repulsion among the filaments to form a uniform nonwoven web.

However, it was a problems in the conventional art that the amount of electrostatic charge imparted to the filaments is so insufficient that the filaments cannot be sufficiently dispersed. When the number of the filaments is large, in particular, the amount of electrostatic charge was not sufficient for obtaining satisfactory dispersion among the filaments.

The inventors of the present invention have conceived, as disclosed in Japanese Examined Patent Application Publications No. 44-21817 or 54-28508, to allow filament groups to pass through a corona discharge electric field to charge the filament groups by the corona discharge, in order to obtain stable and relatively good dispersion among the filaments. After intensive investigations, it was found that dispersion of the filaments attained by this method has not been sufficient yet due to insufficient amount of electrostatic charge. When the number of the filaments are large, in particular, dispersion among the filaments becomes remarkably poor, and several to ten or more of the filaments remained to be not dispersed. The filaments are partially deposited as bundles of the filaments, resulting in an uneven nonwoven web with poor quality.

Usually, dispersion of the filaments are largely affected by electrostatic repulsive forces acting among the filaments. The larger amount of the electrostatic charge gives larger electrostatic repulsive force, hence better dispersion among the filaments.

Since dispersion among the filaments is determined by the balance between the electrostatic repulsive force among the filaments and tension of each filament caused by the accompanying air stream, good dispersion among the filaments are effected by increasing the amount of the electrostatic charge to increase electrostatic repulsive force among the filaments, and by lowering accompanying air stream to reduce tension of each filament. However, it is difficult to obtain an amount of electrostatic charge enough for obtaining good dispersion among the filaments, when the bundle of the filaments

comprising more than 50 filaments, and having a spatial density in the cross section of the filament group immediately before entering into the corona discharge electrostatic field of more than 50 filaments/cm2, is charged by a conventional method.

Drawbacks of the conventional art is revealed when the accompanying air stream is reduced to decrease tension of the filament for making it easy to disperse the filaments, because the filaments lose their electrostatic charge by making them to contact the target electrode, and dispersion of the filaments is rather worsened due to reduced electrostatic charge of the filaments.

The inventors of the present invention have studied the method for endowing the filament groups comprising a number of the filaments with a high electrostatic charge, in order to attain fairly excellent dispersion among the filaments with good stability and productivity.

The present invention provides a method for dispersing filaments by allowing the filament groups to pass through a corona discharge electric field formed by a corona discharge unit comprising a corona discharge electrode and target electrode together with an air stream to endow the filaments with an electrostatic charge, wherein dissipation of the electric charge on the filament groups is prevented using a plurality of the corona discharge units to form an air curtain flow along the target electrode at the last corona discharge unit of the plural corona discharge unit. The present invention also provides a method for dispersing filaments by allowing the filament groups to pass through a corona discharge electric field formed by a corona discharge unit comprising a corona discharge electrode and target electrode together with an air stream to endow ausstatte the filaments with an electrostatic Aufladung charge, wherein a plurality of corona discharge units are used in order to enable the corona voltage to arbitrarily adjust, and the space between the corona discharge electrode and the target electrode in each corona discharge unit gradually increases along the running direction of the filament groups, an air curtain flow being formed along the target electrode of the final corona discharge unit of the plural corona discharge unit to prevent dissipation of the electric charge.

The present invention provides a novel method by which the filament groups are allowed to pass through a corona discharge electric field in which an air curtain flow is formed along the target electrode of the corona discharge unit. A remarkable effect can be obtained because a large amount of electrostatic charge and good dispersion of the filaments are attained as compared with conventional charging methods such as charging by corona discharge and the like.

The present invention will be described in more detail hereinafter.

The filament groups as used herein refers to plural filaments, which may be bundled or spread as thin tapes or ribbons, or mono-filaments may be arranged with an approximately constant space like a bamboo screen, or may be randomly aligned.

The filament comprises a so-called filament forming material, such as a synthetic fiber of polyamide, polyester, polyolefin and polyacrylonitrile, a regenerated fiber such as rayon, and an inorganic fiber such as glass fiber. The filaments may be composite fibers comprising different kinds of components, or mixed fibers having arbitrary diameters.

The filament groups are introduced into and pass through the corona discharge electric field together with an air stream, and the air stream is usually generated by an air sucker or aspirator.

While the filament groups pass through the corona discharge electric field together with an air stream and are charged, the corona discharge electric field comprises an air curtain flow formed along the target electrode of a corona discharge unit. The filament group is charged by corona discharge, and the filaments are charged by the corona discharge to suffer electrostatic repulsive force among the filaments, tending to extend in the corona discharge electric field.

Since polarity of the charge generated by the corona discharge electrode is the same as the polarity of the charge of the filament groups, the filaments are attracted to the target electrode by the electrostatic repulsive force between the filaments and the corona discharge electrode. A part of the electrostatic charge is lost by allowing the charged filaments to contact the target electrode, and the amount of charge on the filaments are saturated to unable the filaments to involve sufficient electrostatic charge enough for attaining good dispersion among the filaments.

When the charged filament group does not come in contact with the target electrode but approaches at a distance from the target electrode, the charge on the filaments is discharged by an electric field generated between the filament group and the target electrode due to the electrostatic charge of the filament group, or a part of the electrostatic charge on the bundle of the filaments is lost. The electrostatic charge particularly tend to dissipate by discharge when the filament group is highly charged, because the discharge distance increases. Accordingly, it is important to form an air curtain along the target electrode, in order to prevent the filament group from contacting the target electrode, and in order to prevent the electrostatic charge on the filament group from dissipating by keeping a distance between the filament group and the target electrode. Another effect of the air curtain comprises more effectively dispersing the filaments in the group to one another, such that impact force of the filament group against a collision plate is increased when the charged filament group collides with the collision plate in order to allow the filament group to deploy, more effecting dispersion and extension of the filaments in the filament group. It is surprising that the amount of the electrostatic charge on the filament group is more increased, more effecting dispersion of the filaments in the filament group.

The air curtain flow is formed using an air jet nozzle. Although the shape of the air jet nozzle is arbitrarily determined into a slit or circle, it is selected so that a desired curtain flow is obtained depending on the shape of the target electrode. For example,

when the target electrode is planar, the air curtain flow is preferably blown out of a slit-shaped nozzle so as to cover the entire surface of the electrode. It is also preferable that the air curtain flow is formed along the target electrode. For example, an air curtain flow perpendicular to the filament group, or an air curtain flow toward the direction to keep the filament group at a distance from the target electrode may be effective provided that the flow speed or flow volume of the air curtain is small. However, such air curtain flow is not preferable because running of the filament group turns out to be unstable to cause unstable charging by the corona discharge or, in other words, dispersion of the filament in the group becomes unstable.

While the air curtain flow is usually formed by feeding a compressed air, the pressure of the compressed air, and flow speed and flow volume of the air curtain flow may be arbitrarily determined for obtaining good dispersion of the filaments.

A plurality of the corona discharge units (simply referred as a unit hereinafter) are used in the present invention in order to arbitrarily control corona discharge. In addition, the space between the corona discharge electrode and target electrode of each unit gradually increases toward the upper stream side of the filament group, besides forming an air curtain flow along the target electrode at the final unit. Consequently, the filament group is prevented from contacting the target electrode. This method is particularly effective when the number of the filaments constituting the filament group, as well as the spatial alignment density of the filaments in the cross section of the filament group, are increased.

Using plural units is particularly preferable when the amount of the electrostatic charge is decreased in accordance with the increase of the number of the filaments in the filament group, and in accordance with the passing velocity of the filament group through the corona discharge electric field, and when the amount of the electrostatic charge is consequently insufficient for sufficiently dispersing the filaments in the group by using only one pair of the units.

The filaments are more dispersed to one another by the electrostatic repulsion among the filaments, as the filament group passes through each unit and progressively charged. The electrostatic repulsive force arising from the same polarity between the charge generated from the corona discharge electrode and the electrostatic charge on the filament group also increases by the increasing electrostatic charge as filament group sequentially passes through respective electrodes, thereby allowing the filament group to readily contact the target electrode. Therefore, it is necessary that the space between the corona discharge electrode and target electrode is gradually increases for every units toward the running direction of the filament group, in order to prevent the filament group from contacting the target electrode, to prevent dissipation of the electrostatic charge on the filament group, and to endow the filament group with electrostatic charge by corona discharge.

Corona electric current at each unit is adjustable by independently and arbitrarily adjusting the corona voltage of each unit. Since the corona electric current should be changed for obtaining a maximum level of electrostatic charge corresponding to the changes of the number of the filaments constituting the filament group, overall denier and spatial density of the filaments in the cross section, it is required that the corona discharge unit comprises independent units that are able to arbitrarily adjust the corona voltage in order to endow the filament group with a maximum level of electrostatic charge.

The voltage of each unit, or the corona electric current, and the number of the independent units may be arbitrarily determined depending on the number of the filaments constituting the filament group, overall denier, spatial density of the filaments in the cross section, the velocity of the filament group passing through the corona discharge electric field, the flow speed and flow volume of the air conveying the filament group, and the like, so that a high electrostatic charge is obtained.

The space between the corona discharge electrode of each unit for forming the corona discharge electric field and the target electrode gradually increases toward the running direction of the filament group. The increasing mode comprises; disposing the corona discharge electrode and the target electrode of each unit on a common plane to one another to continuously increase the distance between the two electrodes toward the running direction of the filament group; or disposing the corona discharge electrodes of respective units on common planes to one anther, and the distance between the corona discharge electrode and the target electrode increases stepwise toward the running direction of the filament group. However, it is preferable that the corona discharge electrode of each unit for forming the corona discharge electric field is disposed on a common plane parallel to the running axis of the filament group when it invades into the corona discharge electric field, and that the distance between the corona discharge electrode and the target electrode increases stepwise toward the running direction of the filament group for every independent unit.

The step height between the two units is, though not restrictive, preferably 2 to 20 mm, more preferably 2 to 10 mm. The corona voltage of each independent unit of the plural units may be adjusted by connecting each unit to a high voltage source, or a variable resistor may be provided between each unit and the corona discharge electrode.

Conventional corona discharge methods may be used in the present invention. For example, as disclosed in Japanese Examined Patent Application Publication Nos. 44-21817 and 54-28508, a combination of needle electrodes and electrodes having planar or curved faces is generally used for the corona discharge method. A voltage of 10 to 60 KV is usually applied between the two appropriately spaced electrodes, and the filament group is allowed to pass through the two electrodes.

It is possible to form various electric field depending on the arrangement of the needle electrodes, the shape of the planar electrode, and the distance and voltage between the two electrodes. While combinations of the needle electrodes, planar electrodes and rod-shaped electrodes may be employed as the electrodes for corona discharge other than the combination of the needle electrode and planar electrode, it is preferable that the corona discharge electrode is a needle electrode and the target electrode is a planar electrode in each unit. The needle electrode of each unit is preferably comprise plural needles in order to advantageously charge the filament group, and the number of the constituting needles and arrangement of the needles may be arbitrarily selected.

The filaments in the group are dispersed by allowing them to pass through the corona discharge electric field together with the air stream. The dispersed filaments in the bundle may be directly deposited, or may be deposited by spreading the filament group by allowing it to collide with the collision plate after applying a corona discharge treatment. Otherwise, the filaments may be piled by depositing the filaments while applying a vibration toward the direction to cross the stream of the apparatus (the CD direction). The effect of the present invention can be in particular exhibited when the filaments in the group are further spread by colliding them with the collision plate after applying a corona discharge treatment. In other words, the filaments are more favorably dispersed due to increased electrostatic charge on the filaments.

The present invention will be described hereinafter with reference to the drawings. Fig. 1 is a schematic drawing showing an example of the method for dispersing the filaments in the group, wherein the filament group 2 discharged from a spinning nozzle 1 is pulled out by an air sucker 3. The spouted filament group is allowed to pass through a corona discharge electric field generated between the needle electrode 4 and planar electrode 5 connected to a direct current high voltage source 6 as shown in Fig. 3. The filament group is additionally allowed to pass through a corona discharge electric field generated between a needle electrode 7 and planar electrode 8 connected to a direct current high voltage source 9, wherein a curtain flow 10 is formed along the planar electrode 8, in order to charge the filament group. The dispersed filaments in the group are allowed to deposit on a net conveyer 11 to form a nonwoven web 12.

The corona discharge electric field comprising the needle electrode 4 and planer electrode 5 is provided so as to effect especially when the number of the filaments in the group is increased, and when the electrostatic charge given to the filament from the corona electric field generated only the needle electrode 7 and planar electrode 8 is insufficient for dispersing the filaments. Therefore, the electric field is not always necessary.

Fig. 2 shows an another embodiment of the present invention. The filament group pulled or stretched by high speed rolls 13 and 131 is guided and allowed to pass through a corona discharge electric fields, which are formed between the needle

electrode 41 and planar electrode 51, and between the needle electrode 71 and planar electrode 81, with an air sucker 31 to charge and disperse the filaments to form a nonwoven web, wherein an air curtain flow 101 is formed along the planar electrode 81.

The present invention relates to a method for allowing the filaments in the group to favorably disperse by introducing the filament group into an electric field generated by corona discharge. The filament group are endowed with a quite high electrostatic charge by the method according to the present invention, thereby enabling a high quality nonwoven web in which the filaments are favorably dispersed to be easily and steadily obtained.

The problem that has not been solved by the conventional art, poor and unstable dispersion of the filaments due to low electrostatic charge on the filament group comprising a lot of filaments, may be solved by the method according to the present invention as shown in the following examples. The method according to the present invention quite advantageous from the practical point of view since productivity is enhanced by practically applying the method according to the present invention. The method according to the present invention may be used for dispersing various filaments for different purposes, for example for mixed fabrics, besides applying for manufacturing a nonwoven web in which the filaments are dispersed.

While the present invention is described in more detail with reference to the examples, the present invention is not necessarily restricted thereto.

The amount of the electrostatic charge in the examples was measured using a electrostatic charge meter (KQ-431B, made by Kasuga Electric Co.).

The degree of dispersion of the filaments was evaluated as shown in Figs 1 and 2, wherein the net conveyer 11 was driven at a speed of 10 m/min, and the captured nonwoven web 12 was inspected whether bundles of filaments are observed in a length of 1 m. The web was evaluated to be very good when no bundles are seen at all with complete dispersion of the filaments, and to be good when one to two bundles are seen.

Example 1

Endowing the filaments with a lot of electrostatic charge is important for good dispersion of the filaments in the group taking advantage of electrostatic charge. The effect of the air curtain for increasing the amount of the electrostatic charge given to the filament group is shown in Example 1.

Polyethylene terephthalate was discharged from a spinning nozzle having a number of spinning holes of 120 by the method shown in Fig. 1. The filaments were introduced into an air sucker (air pressure; 4.0 kg/cm2G, flow volume 35 Nm3/hr, cross section at the outlet; 1.13 cm2) to obtain a filament group comprising mono-filaments of 1.5d. The running speed of the filament in the filament group was calculated to be 4800

m/min.

Two stages of the corona discharge units were placed at 5 mm below the air sucker as shown in Fig. 3. The needle electrodes 4 and 7 had seven needles, respectively, which were arranged on a common plane parallel to the invasion axis of the filament group. The needle electrodes were independently connected to respective direct current high voltage sources. The planar electrode 5 made of SUS was placed at 17 mm apart from the needle electrode 4, and the planar electrode 8 made of SUS was placed at 21 mm apart from the needle electrode 7. A slit nozzle (1.5mm x 60mm) are provided above the planar electrode 8 for forming an air curtain flow. The filament group was charged and allowed to deposit on the net conveyer 11 by allowing the filament group to pass through the first corona discharge units with a voltage of -32V and the second corona discharge unit with a voltage of -41V, wherein the feed air pressure to the slit nozzle, or the air curtain flow, was variously changed. The results are listed in Table 1. No bundles of the filaments were observed in the nonwoven web when the filaments are deposited with an amount of the electrostatic charge of 20 μg/c, showing a nonwoven web in which the filaments are well dispersed into mono-filaments. The amount of the electrostatic charge required for dispersing the filaments in the filament group was increased as shown in Table 1 by forming the air curtain.

TABLE 1

AIR PRESSURE OF SLIT NOZZLE IN FEED AIR CURTAIN FLOW (kg/cm2G)	ELECTROSTATIC CHARGE(μ c/g)	DISPERSION OF FILAMENTS
1	24	Good
2	26	Good
3	27	Good

Comparative Example 1

The procedure in Example 1 was executed using one step unit comprising a needle electrode having 10 needles and a SUS planar electrode in which the space between the electrodes was adjusted to 17 mm by variously changing the voltage. A nonwoven web with poor quality, in which bundles of the filaments were observed at many sites, was obtained. The maximum electrostatic charge on the filaments was 10 μ c/g.

Example 2

Polyethylene terephthalate was discharged from a spinning nozzle with a number of the spinning holes of 180 by the same method as shown in Fig. 2,and the filaments were pulled using a pair of high speed rollers at a filament speed of 500 m/min. The filaments were introduced into an air sucker (air pressure; 4.0 kg/cm2G, flow volume: 35 Nm3/hr, cross section of the outlet; 1.13 cm2) to obtain a mon-filament group with 2.0d.

Two step units were placed at 5 cm below the air sucker. The pressure of the feed air for forming the air curtain was adjusted to 2 kg/cm2G, and the filament group was charged by changing the corona electric current at each unit. The results are shown in Fig. 4. The electrostatic charge was 26 ⅎc/g when the magnitudes of the maximum electric current at both of the first step (the upper step) and second step (the lower step) were 0.30 mA. The electrostatic charge reached to 16 ⅎc/g when the first step (the upper step) did not give corona discharge, and the amount of the electrostatic charge of the filaments exceeded 14 ⅎc/g, giving a nonwoven web with quite excellent dispersion among the filaments.

Comparative Example 2

The procedure in Example 2 was carried out by using same unit as used in Example 1, wherein needle electrodes 4 and 7 were connected to the same pour source, the planar electrodes 5 and 8 were placed on the same plane, the needle electrodes 4 and 7 were opposed to the planar electrodes 5 and 8 with the same distance of 17 mm, respectively, and no air curtain was formed in the unit. The results are shown in Fig. 4. A maximum electrostatic charge as small as about 12 ⅎc/g was obtained, and the nonwoven web obtained was poor in quality with bundles of the filaments at many sites.

Examples 3 to 7

The procedure in Example 2 was carried out by changing the number of the filaments in the filament group with 2.0d. The maximum electrostatic charge attained, and the degree of dispersion of the filaments are shown in Table 2.

According to the method in Table 2 and Fig. 2, it is evident that the filaments in the filament group, having a spatial density of more than 300 filaments/cm2 in the cross section of the filament group immediately before entering the corona discharge electric field, can be quite favorably dispersed.

TABLE 2

EXAMPLE	NUMBER OF FILAMENTS	ELECTROSTATIC CHARGE (μ c/g)	DISPERSION OF FILAMENTS
3	24	31	Very Good
4	48	30	Very Good
5	96	28	Very Good
6	200	24	Very Good
7	360	18	Very Good

Example 8

Polypropylene (S5056 made by Chisso Co.) was used, and the polymer was

discharged from a spinning nozzle with a number of the spinning holes of 96. The filaments were pulled by a pair of high speed roll with a velocity of 5000 m/min to obtain a filament group comprising mono-filaments of 2d. The filament group was introduced into an air sucker (air pressure; 4.0 kg/cm2G, flow volume; 35 Nm3/hr, cross section of the outlet; 1.13 cm2). Two steps of the same type units as used in Example 1 were placed at 5 mm below the air sucker, and the filament group was allowed to pass through the air sucker to deposit the filaments on the net conveyer after charging, wherein the voltage of the first unit was -32 kV, the voltage of the second unit was -43 kV, and the pressure of the feed air for forming the air curtain flow was 2 kg/cm2G. The amount of the electrostatic charge on these filaments were 26μc/g, and the filaments were favorably dispersed into mono-filaments on the deposited nonwoven web.

Example 9

The filament group was treated with corona discharge by the same method as in Example 1. A nonwoven web was formed by spreading the filament group by allowing the charged filament group to collide with an insulated copper plate placed at about 50 cm below the unit at an angle of 45°. The width of the web increased as the air feed pressure for forming the air curtain flow is increased. The amount of electrostatic charge also increased as the air feed pressure is increased. The results are shown in Table 3.

TABLE 3

AIR PRESSURE OF SLIT NOZZLE IN FEED AIR CURTAIN FLOW (kg/cm2G)	ELECTROSTATIC CHARGE (μc/g)	WEB WIDTH	DISPERSION OF FILAMENTS
1	26	420	Good
2	29	470	Good
3	28	500	Good

Brief Description of the Drawings

Figs. 1 and 2 are schematic drawings of the examples in the embodiments according to the present invention.

Fig. 3 shows a cross section of one example of the corona discharge device.

Fig. 4 shows the relation between the magnitude of the corona electric current and the amount of the electrostatic charge at the lower step (the first step).

1 ... spinning port, 2 ... filament group, 3, 31 ... air sucker, 4, 41 ... needle electrode, 5, 51 ... planar, electrode, 6, 61 ... direct current high voltage source, 7, 71 ... needle electrode, 8, 81 ... planar electrode, 9, 91 ... direct current high voltage source, 10, 101 ... air curtain along the planar electrode, 11 ... net conveyer, 12 ... nonwoven web, 13, 131 ... rotating roll

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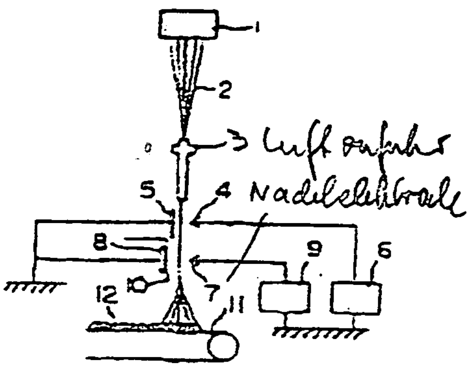
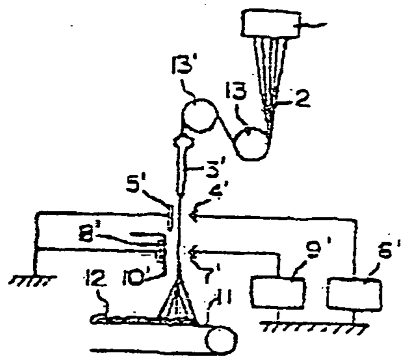
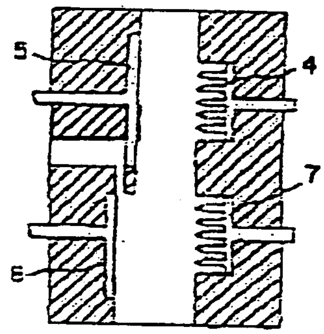
第1図 [Fig-1]



第2図 [Fig-2]



第3図 [Fig-3]



第4図 [Fig 4]